Consolidated Object Standards

Strategic Plan

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Executive Summary

The Strategic Plan for the Consolidated Object Standards project outlines the shared vision for developing and managing object standards, defines the primary goals and objectives of the project, establishes measures of performance, and proposes strategies to accomplish the goals. This plan encompasses the breadth of domains consistent with the definition of facilities, infrastructure, and environment and presents the Center's approach to leverage government, industry, and academic initiatives in object technology to consolidate standards into a single standard for objects common to the design, construction, operations, and maintenance of facilities, infrastructure, and environment.

The Center developed the A/E/C CADD, SDSFIE, and FMSFIE standards using the latest technologies available at the time. From these efforts, the Center learned that standards development and maintenance is difficult, complex, and expensive. CADD and GIS technology is changing from the relational based approaches used when the standards were developed. The new technology, known as object technology, has been adopted by CADD and GIS COTS software. Objects extend the relational technology making relational based standards difficult to implement and limiting the software capabilities. For these reasons relational standards will be ignored in the near future. International standards organizations are already developing standards that conform to the new object technology.

There remains a need for CADD and GIS standards that are implantable in COTS software. However, Center funding cannot support standards development using the methods of the past. Also, standards should not be so sensitive to technology that changing technology causing a new standards initiative. The Center proposes another standards development method to:

- Economize the standards development process for government agencies.
- Leverage industry efforts to help develop standards.
- Augment industry standards with government requirements.
- Simplify standards implementation for users.
- Use standards-compliant COTS software to implement standards.
- Broaden standards use and compliance in government agencies.
- Use industry certification programs to enforce standards compliance.
- Maintain standards compliance as technology evolves using requirements based model.

The plan consolidates new Center standards development activities and leverages existing work in reputable standards organizations having government, industry, and academia members. New standards will be incrementally developed and implemented using current technology. Reputable standards organizations are those that regularly produce standards adopted by COTS software developers and maintain a certification program to register compliant tools. Using national and international standards organizations will enable the government to augment industry standards with particular government requirements. The obvious benefit is that the government realizes a reduction in overall cost to develop, maintain, and enforce standards. Standards compliant software provides interoperability between the tools used in engineering processes, regardless of technology changes. The primary limitation of this approach is that incremental progress in standards development will be slower due to the larger group participating in standards development.

The vision of the strategic plan was to specify consolidated standards goals, to propose objectives that would indicate progress toward comprehensive CADD and GIS standards, and to describe strategies that are the "next step" toward meeting the objectives. The plan appendices provide to the reader with enough information about object technology and its application to review the strategy document.

The plan is subdivided into five goals. Each goal addresses a major area of effort required to successfully accomplish the vision. The Management Goal optimizes the object standard development process. The Technical Goal insulates the new object standards from implementing technology, thus making standards adaptable to future technologies. The Marketing Goal promotes Center object standards as a viable cost efficient means for improving engineering and facilities management processes. The Partnering Goal promotes collaboration with other standards organizations to minimize government effort and leverage industry standards development efforts. The Quality Goal establishes and enforces object standards compliance criteria by leveraging certification programs in industry standards organizations.

The document contains the strategy description and three appendices. The strategy description contains a technical description of the goals, objectives, and implementing strategies. Appendix A summarizes the Center projects that depend on object technology. Appendix B provides a tutorial on the breadth of object technology and the focused approach the Center will take to define object standards. Appendix C contains a glossary of terms used in the document.

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Preface to 30 Sep 2001 Version

This edition of the strategy document incorporates recommended changes from previous editions. In brief, these changes include editorial changes that improve clarity, removal of superfluous material, and reorganization of the document. The substance of the strategy has not changed.

The document structure changed to isolate information for quicker reference. The Executive Summary encapsulates the strategic thrusts and summarizes the strategy. The document body describes the strategy without any background information. Background information is segmented in the appendices. Appendix A contains brief descriptions of Center projects that in some way affect or influence the consolidated object standards project. Appendix B contains material that explains object technology sufficient for a non-technical person to comprehend the purposes of the objectives, goals, and strategies. Appendix C contains a glossary of terms that are unique to object technology or the strategy of the consolidated object standards project.

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Introduction

The CADD/GIS Center for Facilities, Infrastructure, and Environment (the Center) annually solicits proposals for projects that will increase the efficiency of design, construction, operations, and maintenance processes for Facilities, Infrastructure, and Environment (FIE). Analysis of these proposals for FY01 indicates an opportunity to leverage the emergence of object technology in COTS software products by emphasizing software interoperability. This document is a product of Center initiated Project 01.044 (Consolidated Object Standards). The purpose of Project 01.044 is to develop and implement a strategy, acceptable to the Corporate Staff and the Board of Directors. The strategy portrays short and long-term actions of the Center necessary in the area of object technology in order to incorporate CADD, GIS, and FM standards into COTS products used to design, construct, operate, and maintain processes for FIE.

Information in this strategic plan presumes general technical knowledge about Object Technology and Object-Oriented (OO) software development processes. The background section presents rationale for a Consolidated Object Standard (COS) strategy from managerial and technical perspectives. The section on purpose and scope presents the ultimate breadth of influence of the COS project. The strategic direction enumerates the goals, objectives, and strategies of the project. Appendix A contains an overview of object technology. Appendix B contains an overview of OO software development. A glossary is contained in Appendix C.

Background

This section provides the rationale for a COS project. A managerial perspective will be presented first followed by a technical perspective. The technical perspective will use terms and concepts found in the appendices.

From these efforts, the Center has learned that standards development and maintenance is difficult and expensive. Common methods or tools do not support standards development. Standards adoption by operating facilities costs time and money. Costs are incurred by changing the business process, converting legacy data to a standard structure, and acquisition of and training on compliant tools. Resources used to convert to a standards based business process are the most valued in the business function. These resources are in short supply and the migration to compliant data structures is often an incremental process.

Persistent contact and support from the Center has been the means for successful adoption of standards. Standards adoption and compliance is hampered by limited support in COTS software. The Center has had to invite software vendors to participate in the standards development process with little or no assurance that the full standards will be compliant in future products.

Standards robustness is limited to changing computer technology. This reason for this document is caused by the introduction of objects into all COTS software. The A/E/C CADD, SDSFIE, and FMSFIE standards were developed using a data-oriented relational technology. This has caused these standards to contain some implantation characteristics that will not migrate to another technology (e.g., object technology).

Center Standards Efforts

The CADD/GIS Center for Facilities, Infrastructure, and Environment has a core mission of developing standards. Since FY96, the Center has been maturing the A/E/C CADD Standards and the Spatial Data Standards for Facilities, Infrastructure, and Environment (SDSFIE). The A/E/C CADD Standards conform to and extend the National CADD standards developed by the National Institute for Building Standards (NIBS). The Spatial Data Standards are being reviewed by ANSI to become an ANSI standard.

The A/E/C CADD Standard has been developed by The CADD/GIS Technology Center to reduce redundant CADD standardization efforts within the Army, Navy, Air Force, and Corps of Engineers. The standard is part of an initiative to consolidate existing CADD drafting standards into a format generic enough to operate under various CADD software packages (such as MicroStation® and AutoCAD®) and to incorporate existing industry/national standards. The A/E/C CADD Standard includes presentation graphics, level/layer assignments, electronic file naming, and standard symbology. In the final phase of the standards development, platform-specific software will be provided to aid the user in implementing the standards. In addition, non-graphic attribute data will be developed as part of the standard.

The SDSFIE provide a standardized grouping of geographically referenced (i.e., geospatial) features (i.e., real-world features or objects depicted graphically on a map at their real-world location (i.e., coordinates). Each geospatial feature has an "attached" attribute table containing pertinent data about the geospatial feature. The standard is the only "nonproprietary" GIS standard designed for use with the predominant commercially available off-the-shelf GIS and CADD (e.g., ESRI ArcInfo and ArcView; Intergraph MGE and GeoMedia; AutoDesk AutoCAD, Map and World; and Bentley MicroStation and GeoGraphics), and relational database software (e.g., Oracle and Microsoft Access). This nonproprietary design, in conjunction with its universal coverage, has propelled the SDS into the standard for GIS implementations throughout the Department of Defense (DoD), as well as the de facto standard for GIS implementations in other Federal, State, and local government organizations; public utilities; and private industry throughout the United States and the World.

In FY98, the Board of Directors authorized work to begin consolidating the Center's CADD, GIS, and FM standards. Requirements for CADD, GIS, and FM are quite different and are often separated within a software vendor's product line. Integration of CADD, GIS, and FM would have a dramatic impact on the legacy software of the vendor causing unacceptable costs to change the software and unacceptable delays in producing the next product release. The apparent rational notion of integrating CADD, GIS, and FM standards requires substantial work to define representations that can work for legacy software and next generation software. Rather than synthesizing CADD, GIS, and FM requirements to produce a consolidated standard, the work will need to integrate the requirements so that a single representation for CADD, GIS, and FM can produce current standards definitions and a consolidated standard definition.

Technology Influence on Standards Efforts

Business processes in government and industry are being reengineered to minimize redundant effort, redundant data maintenance, and redundant, even conflicting, functions. Many organizations have tried to implement an enterprise solution (through GOTS or internal development efforts) by focusing on data modeling and identifying the business function or office that creates, reads, updates, and deletes the data. However, these activities often failed to identify operations or activities within the function or offices that create, read, update, and delete the data due to funding restrictions or the difficulty of specifying process details to the activity level (it was too hard). Because of this data-centric approach, when the operation or activity changed, data requirements often changed causing chaos in maintaining data models and redesigning databases.

Rather than try to reengineer the entire suite of FIE lifecycle processes and build a complete suite of automated systems to meet the new requirements, the Center will leverage the development capital of COTS software developers, the organization of current standards groups, and the specifications for FIE lifecycle processes to include government requirements in COTS software. The COTS software developers are currently conducting software redesign efforts that migrate to Object-Oriented (OO) architecture. Standards organizations are trying to identify objects that should be included in these COTS software packages. The Center will identify standards organizations and FIE domains that will enable incorporation of government requirements into the standards. Software that adopts the standards will include standard government and industry requirements. Having this software commercially available will dramatically reduce software investment by the government.

To realize enterprise-wide savings, software packages must interoperate. As with most new technologies, object technology must be precisely managed to provide the high payback expected. Object technology is the most recent in a long line of information technologies that have promised solutions to business problems. Object technology can provide interoperability using standard objects that are implemented in the COTS software and communicated between software packages using standards in a metadata language, like XML. Therefore, to improve the FIE lifecycle processes, the enterprise will need to commit to interoperability. Object technology can implement this interoperability through standards. However, without standards, object technology will provide marginal value to the enterprise and will require continued development and maintenance on utility conversion software to migrate data from one software package to another.

Current Object Standard Activities

The Center began developing standard objects through Project 96.245 (AEC Object Standards). This project has established the Center as a leader in getting standards into software. Using charrettes, the Center-chaired Facilities Management domain of the International Alliance for Interoperability (IAI) developed objects needed for moving personnel, equipment, and infrastructure from one office or building to another office or building.

While the current standards are continuing to be refined (Projects 96.013, 96.015, 96.017), the Center is beginning to focus on the migration to object-oriented standards. Other Center projects, Project 96.015 (Component 9), Project 98.125, and Project 01.039, are addressing standards integration issues. It has become apparent that a consolidated approach to standards development is necessary to accomplish the FIE life cycle processes. A summary of relevant project activity is contained in Appendix A.

Purpose & Scope

Purpose. The Consolidated Object Standards Strategic Plan provides overall technical guidance for developing and directing the CADD/GIS Center for Facilities, Infrastructure, and Environment Consolidated Object Standards project and all other projects using object technology. The plan outlines the shared vision for developing and managing object standards, defines the primary goals and objectives, establishes measures of performance, and proposes strategies to accomplish the goals.

Scope. This strategy document is the Center's unified approach for applying object technology to the development and maintenance of CADD, GIS, and FM related standards that will be adopted by developers of automated software products used to design, construct, operate, and maintain FIE. The strategy includes management of the projects, technical aspects of the consolidated standards model, incentives to develop and use standards compliant products, collaboration approaches for work with other organizations, and quality control. The strategy is product oriented to enforce relevance of the Center's approach to the needs of working architects, engineers, planners, and facilities managers. The overall thrust of the strategy concentrates on partnering and collaborating with efforts outside the Center to maximize the value of products and reduce or eliminate duplicate government efforts. The Center will

collect FIE requirements and infuse these requirements into the appropriate effort in an industry standards organization. The strategy is independent from technology or implementation. Compliance criteria are required to create trust in the standards and products that implement the standards. Finally, mechanisms that encourage use of compliant products are required to initiate implementation of standards and initiate use in the government enterprise.

Strategic Direction

Mission Statement. The Center's mission focus is on coordination of capabilities throughout DoD and the federal, state, and local governments for the accomplishment of specific tasks and application developments where appropriate. This includes setting standards, promoting system integration, supporting centralized acquisition, and providing assistance for the installation, training, operation, and maintenance of CADD/GIS and facilities management (FM) systems. This also includes supporting software development projects, promoting communications, developing and promoting standards, furnishing technical advice, interfacing with professional organizations and industry, evaluating technological developments, and recommending necessary CADD, GIS and FM policy to insure the maximum benefits are received from these technologies.

Vision. The overarching motivation of the Consolidated Object Standards project is to standardize objects used by all organizations that design, construct, operate, or maintain facilities, infrastructure, or the environment in order to share common data and functions between process activities within the enterprise and seamlessly transfer data between consumer and supplier. This means that a component of a building, like a window, is 1) modeled, placed, specified, and moved in the design process; 2) is replaced with a model of the actual window that was installed in the actual building during construction; 3) is a factor for HVAC operations; and 4) is cleaned, repaired, and replaced as a part of maintenance. The same window object is used throughout the life cycle of the facility but characteristics change over time. This enterprise approach to interoperability is best achieved through compliant GOTS and COTS products providing organizations a selection of tools that do not inhibit data and function sharing.

An overview of the strategy is contained in Figure 1. The arrows denote the beginning of work in the domain. Once work begins in the domain, it is expected to continue and improve the standards over time. The figure is subdivided into three areas that denote eras in standards development.

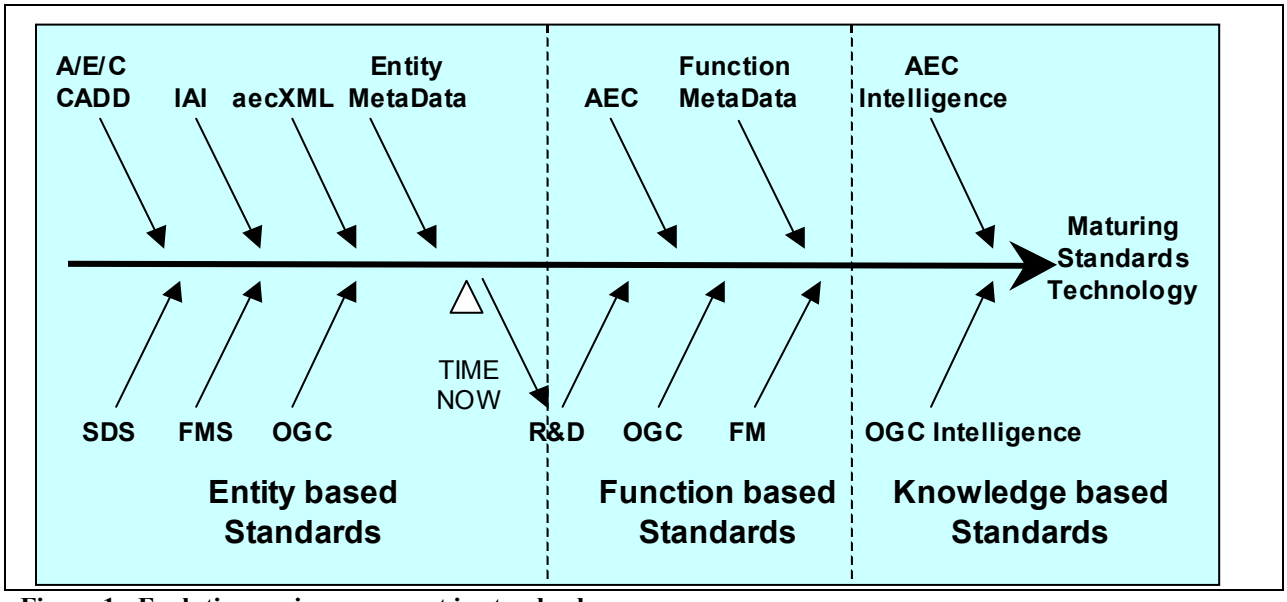

Figure 1 - Evolutionary improvement in standards

The left side of the figure denotes the current era in standards development. In the current era, data models and early object standards contain entities that should translate to entity objects. These objects are data oriented with little or no functionality. Standards efforts will capture these entity objects and retain them using an object model. Up to the present time, indicated by the "TIME NOW" marker, Center standards and products of industry standards organizations have contributed to the progress of standards development. These standards need to be consolidated, semantics captured and retained, and research and development (R&D) projects initiated that will further enhance standards, especially object standards. R&D projects should be using the standards developed as well as contributing to the improvement of the standards.

The center portion of Figure 1 denotes the next standards era. In this era, standards developing organizations identify standard functions that extend the definition of the standard entity objects developed in the prior era. Results of R&D projects are used to improve the standards, standards development, evaluation, and maintenance. Encapsulating standard functions with the entity objects produce objects in the form commonly portrayed in the literature. Standardizing functions infers that government and industry agree on a single algorithm for the object's operation e.g., physics based model. Those objects unique to the government, if any, would be a minor augmentation to the basic industry standard.

The right side of Figure 1 denotes the current horizon of the object standards vision. In this era, standards are augmented with knowledge management and knowledge discovery technology. Standards are implemented using intelligent agents that behave as assistants to the software user, delivering to the user as needed, anticipating needed information, performing menial tasks for the user without user interaction, and conducting engineering analysis to proactively alert the user to dangers based on the organization's engineering criteria (e.g., building codes and standards). The Consolidated Object Standards project does not participate in implementation strategy for the standards but current technology would indicate object delivery through portal tools.

Goals, Objectives, and Strategies. The following goals, objectives, and strategies are the currently recognized requirements needed to meet the vision. Goals describe areas of major change that will require significant time to complete. Each goal statement is a dimension of the vision. Together the goals provide a full understanding of the scope of effort needed to meet the vision. Each goal statement is followed by a description of objectives and strategies. Objectives characterize broad actions needed to pursue each goal, while strategies characterize specific actions needed to accomplish each objective. Objectives and strategies should not necessarily be accomplished in chronological order but can be implemented in parallel. Strategies are relatively short duration actions that are critical to meeting the objective. The following goals, objectives, and strategies are the framework that enables the Center to focus resources on developing object standards.

Goal 1 (Management) Optimize Object Standard Development Process

This strategic goal establishes a management framework for developing object standards in the CADD/GIS Center. The Center develops several different standards for facilities, infrastructure, and environment (FIE). Current versions of the Spatial Data Standards (SDS) for FIE and Facilities Management Standards (FMS) for FIE were developed using IDEF1X data modeling techniques recommended by the Department of Defense. Current AEC CADD standards are generic enough to operate within various CADD software packages and incorporate existing industry/national standards. International AEC standards organizations are using object technology to develop models. This goal will modernize Center modeling techniques while maintaining conformance with DoD data standard requirements.

Objective 1.1 Eliminate Duplicate Object Standards Efforts

The CADD/GIS Center has successfully developed standards for A/E/C CADD, spatial data, and facilities management using models closely related to implementing technology. This approach is acceptable when GOTS products could be produced that augmented COTS products. In the next generation of standards, the Center will collaborate with partners in an electronic alliance that requires complete reliance on interoperable COTS products. This objective will develop a single process to develop and manage standards using object technology.

Strategy 1.1.1 Initial Consolidation of Center Object Standards Work

To facilitate migration of the Center standards development process to object technology, all current efforts of migrating entity-based standards to objects will be consolidated into one project within the Center's Core Mission. Mission Related projects using object technology will coordinate with the Core Mission project and subscribe to the contemporary version of this strategy document. These management actions will provide a singular approach to the object efforts in the Center. Managers of these projects will coordinate activities such that products of the core mission project will be implemented and used in products of the mission related project. The management structure will be a stable structure that will migrate to the technology that will replace objects.

The Center will develop a process of transferring technology to customers through the standards definitions and operational products. Standards implementing projects will document the success of implementing standards to produce a "lessons learned" database and a rationale for standards improvement.

Strategy 1.1.2 Use a Single Object Modeling Method

The Unified Modeling Language (UML) and Express-G are the popular modeling languages of standards organizations. The Center will use UML because data structure, object behavior, relationships, and metadata text can be stored in a singular tool. This preserves standards knowledge for review and analysis. A capable tool will be able to generate code for more rapid prototype development. The model will be in a form that can be migrated to the next technology.

Strategy 1.1.3 Future Consolidation of Center Standards work

The Center will eventually manage consolidated standards using a collaborative approach and a consolidated modeling tool. At the same time standard objects will begin to contain standard functions that manage the data of the entity objects. The Center will identify individual Core Mission projects that will manage the maturation of standards. These projects may not be in the same form as current Core Mission projects due to the changing nature of the industry and the Center customers. The Center and Corporate Staff will propose these projects to the Board of Directors at the proper time to separate the effort. An individual of the Center staff will coordinate all standards work.

Objective 1.2 Improve Formal Internal Technical Communications between CADD/GIS/FM Projects

Consolidation of projects based on a singular foundational technology, like objects, is the primary focus of this strategic plan. Object technology will impact other Center projects. All technical knowledge in the Center should be shared to build a singular product delivery approach by the Center. Internal technical communications in the Center will need to continue or improve to alert all projects of domain trends and implementation technology trends. An objective of Goal 1 is to better share engineering knowledge and implementing technology in Center operations.

Strategy 1.2.1 Convene FUG Chairs

A Field User Group (FUG) concentrates on Center priorities within an FIE field. This strategy will work to improve "cross pollination" of ideas between the FUG representatives. The FUG chairs will convene at least annually to consider the advances in implementation technology and analyze the impacts on their field of expertise. Every FUG chair will be notified of Object technology products and will be requested to determine applicability to the FUG mission. This feedback will stabilize the direction of the object technology projects to better serve the Center customers.

Strategy 1.2.2 Provide draft standards to other domains

All object technology draft products will be provided to FUG chairs for review and comment. The FUG chairs will be expected to comment on drafts in order to minimize the impact on users when object technology is implemented.

Objective 1.3 Coordinate Technical Project Products

Object technology products will be coordinated through the consolidated projects to demonstrate adherence to this strategic plan. Products will consist of those developed by the Center and those developed and delivered by partners (e.g., industry partners). The Center web presence will be the predominate vehicle for knowledge dissemination. Through work with portals, the Center will supply a mechanism for knowledge access where subject matter experts will provide and maintain the content.

The Center has produced products that meet or exceed expectations of customers. All products need to have a criteria for quality that, when met, indicates that the product is ready for release. The following strategies concentrate on maintaining these criteria for product quality improvement.

Strategy 1.3.1 Improve Product Requirement Descriptions

Center project proposals will contain a list of deliverables and a description of each product. The Corporate Staff and the Board of Directors will then have a better understanding of the products of each project. The Center management will also have criteria for determining the status of the product for reporting purposes and determination of product release. References to existing written requirements will be encouraged to make the requirements description more concise.

Strategy 1.3.2 Leverage work to benefit multiple products

Due to the nature of objects and their propensity for reuse, each Center project effort using objects is expected to contain potential benefits for other projects. Therefore, all Center projects will be analyzed by Center Staff to determine results that can be reused. Products produced by the Center will be available for reuse and the alliance of the Center with industry partners is expected to produce reusable results. Placing an emphasis on reuse is expected to improve the value of Center products while reducing unit cost and time to market.

Goal 2 (Technical) Insulate Object Standards from Implementing Technology

This strategic goal establishes a framework for the technical production of object standards. Current Center standards were developed using a data modeling approach that is being replaced by object modeling. It is expected that object technology will someday be replaced by another technology. The object standards will need to be developed and maintained in a form that is divorced from the implementing technology to stabilize standards definition and minimize the effort to convert to the next technology.

A standards metadata model can provide this requirement for an overarching standards language. Migrating the current entity-based standards to a metadata language would require a great deal of effort. Object modeling techniques provide a means to collect and maintain more standards metadata than the entity-based approaches. This strategic goal identifies areas needing concentrated effort to make standards models more robust in this dynamic technology age.

Objective 2.1 Reuse Legacy Data in Consolidated Standards

The first step to insulate standards from implementing technology is to consolidate the current standards into a single model. This model can be either a data model or an object entity model. The model will eventually become an entity object model. This entity object model will contain the entity structure, entity relations, relationship cardinality, data dictionary, and rationale for data entities, data elements, and relationships. The final entity object model will contain the A/E/C CADD, SDSFIE, and FMSFIE models with no redundant information. This object model will contain the relationships between CADD entities, SDSFIE entities, and FMSFIE entities. These relationships will be valuable information when determining how to implement standards for customers.

Entity objects define and describe the data needed for the problem domain with little or no functional interfaces. Since objects encapsulate data and function, this initial integration of current entities into object modeling will be a baseline for additional work to identify and standardize object functions. This baseline will also be used to manage all new additions to the standards.

Strategy 2.1.1 Migrate Current Center Entity based Standards to Objects

Developing standards using this new technology requires a change in the formal process. The first step toward implementing this new process is to migrate legacy information to the new technology. This operation will form the genesis of domain boundaries in the consolidated object model. As illustrated in Figure 2, current entity-based standards will comprise the initial object model in the form of an entity object model. The current SDSFIE and FMSFIE standards are expected to significantly overlap, i.e. have common entity objects. The AEC CADD standard is expected to have some overlap with the other standards.

Migrating current standards to object modeling requires

- Acquisition of a modeling tool that, as a minimum, can import existing entity models, create entity objects, augment these objects with functional interfaces, maintain model, object, and data element metadata, produce data models conforming to DoD requirements, maintain a single model having partitions for each domain model, provide multi-user operations, and provide configuration management of versions.
- Importing current Center standards models into the tool, reconciling differences, and identifying missing information.
- Importing current standards models produced by international standards organizations into the tool, reconciling differences, and identifying missing elements
- Proposing approaches to resolve the differences and supplying missing elements in the standards model.
- Proposing approaches to transfer standards to Center customers.

The methods for accomplishing the import, resolution of differences, and technology transfer should be accomplished through core mission and/or mission-related projects.

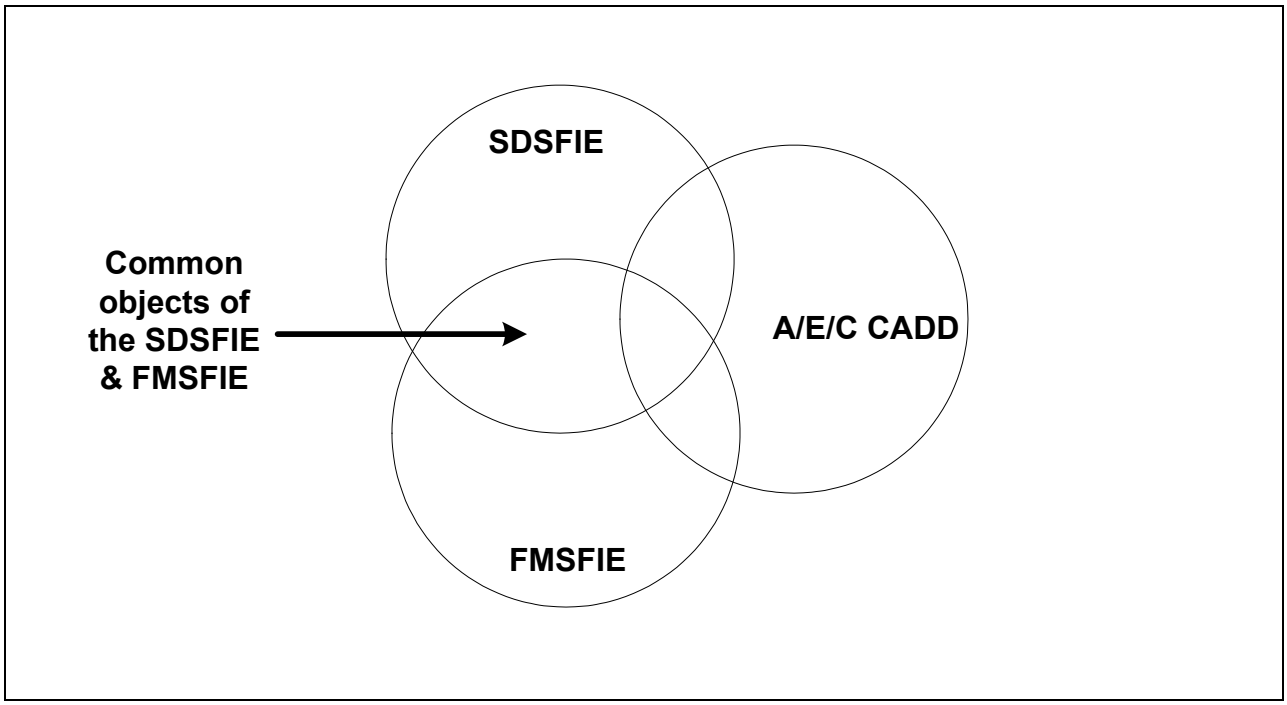

Figure 2 - Interrelationship between Center Standards

Strategy 2.1.2 Identify Areas needing Work

The consolidated object model developed in Strategy 2.1.1 is not expected to be complete. There are expected to be areas that have been excluded from work due to constraints. These will be identified and documented in order to put the effort into the process for funding consideration.

Strategy 2.1.3 Identify Areas Duplicated/Conflicting

The consolidated object model developed in Strategy 2.1.1 is not expected to be complete. The missing data and conflicting data will be identified and documented. Center personnel will analyze these anomalies and develop resolutions. Center representatives will present these resolutions to standards organizations and work with the organizations to resolve these duplications and conflicts.

Strategy 2.1.4 Produce a Clean Initial Model

The baseline model produced through Strategy 2.1.1 and updated through Strategy 2.1.2 and Strategy 2.1.3 should provide the information necessary to develop a full and complete baseline model. The model must be validated for complete compliance to the intent of the SDSFIE, FMSFIE, and AEC CADD standards. The result of this work will be a full and complete validated baseline model for all following object standards work.

Strategy 2.1.5 Produce Standards from a Consolidated Model

To prove that the consolidated model developed in Strategy 2.1.4 is a faithful representation for the standards, the entity-based standards must be derived from the model. Once the entity object model is developed with all duplicate entity objects and data element redundancy removed, a Center user should be able to select the SDSFIE entity-based standard, the FMSFIE entity-based standard, or the AEC CADD standard from the entity object model. This operation is similar to the current tools used with the SDSFIE and FMSFIE standards.

Strategy 2.1.6 Incorporate other Standards

The Center can integrate other object standards through Objective 4.1 into the consolidated model to identify conflicts and redundancy. Center participation with other standards organizations should facilitate the reduction of redundant standards development efforts, ultimately producing interoperable standards.

Strategy 2.1.7 Integrate Data and Behavior

As the Center standards mature, objects in the consolidated model will be augmented with other objects and standard functions. These standard functions will mature from the obvious functions of drawing the object, storing values in the object, and getting values from the object, to the more useful functions like finding an item in the database, computing a design load, and finding a supplier for the item.

Since the Center and international standards organizations have not yet begun defining standard functions, this effort by the Center will be valuable to all standards organizations as a clearinghouse for integrated object standards. The Center will not be expected to resolve differences but will be a major player in other standards organizations to identify where differences exist and the conflicting standards.

Objective 2.2 Manage Standards in a Metadata Language

A metadata language, like XML, is able to describe semantics and can describe the meaning of objects. Just as geospatial metadata adds value to geospatial data, object metadata can add value to object standards. Using a metadata language the Center will capture the standards, models of the standards, and the purpose of each item in the models of the standards. Having the purpose for an item in a model lends more meaning to the item and enables better communication between personnel about the models. This communication is imperative, as the Center becomes a collaborator with other standards organizations. A metadata model abstracts the original object model to a level that will be transferable to the next technology.

Strategy 2.2.1 Define a CADD/GIS/FM Interoperable Data Language

The AEC CADD community has developed means to share data between CADD software. The IAI has successfully developed an object class library that shares information between software products. The OGC is developing standards for data interoperability. GDL is an open language from Graphisoft that can be used to transport object data. These interface formats infer knowledge that is not explicitly contained in the files. A model containing this knowledge will benefit future standards efforts by documenting past knowledge to future practitioners. Integrating this knowledge, through the operations of Strategy 1.1.2, enables the model to serve as a knowledge base of engineering information. To preserve this knowledge from technology changes, the model language must not be closely tied to software implementation.

This strategy does not suggest development of a new computer or modeling language. This strategy states that the Center will use a language for all standards models that supports interoperability. To date, the language of choice is the Unified Modeling Language (UML) due to its relative maturity and support through automated tools. Other languages may need to be considered and compared with UML. The Consolidated Object Strategy project emphasis is to integrate object products. Just as engineers need automated tools for analysis and design, the Center needs automated tools for consolidation, analysis, and design of standards. The tools must be interoperable and conform to the requirements identified above.

Strategy 2.2.2 Produce Standards Documents from the Object Model

The consolidated model will be augmented to become a consolidated object model. Augmenting the object model will enable other engineering domain standards to be defined. This approach enhances standards quality by producing an interface for the extracted object standard. Interfaces are essential for software interoperability and provide software developers access to standard objects used in their applications. (I don't understand this strategy at all! It seems to me that several different ideas are being presented in this one paragraph – standards documents, augmenting the object model, and producing an interface – and I don't understand the relationship among these ideas.)

Goal 3 (Marketing) Promote Center Object Standards

This strategic goal establishes a framework for promoting the adoption of object standards by automated engineering tools vendors and the use of object standards by government agencies. Use of the SDSFIE, FMSFIE, and A/E/C CADD standards are varied. The A/E/C CADD standard is compliant with the national CADD standard that is expected to become an ISO standard. The SDSFIE is expected to become an ANSI standard.

These Center standards are extremely useful to organizations that demand interoperability. Object standards will also satisfy interoperability demand through software function in a multiprocessing operating system like Microsoft Windows 2000 or Unix and its derivatives (e.g., Linux). Object standards will also reduce software development cost through software reuse. Since object standards are directly implemented through software languages, vendors are expected to implement the standards rather than burden the user community to implement standards.

Objective 3.1 Deliver Standards to Customers using Implementing Software

Government and industry have developed automated engineering tools. Due to the unacceptable life-cycle cost of internally developed software, the government has adopted an acquisition policy placing a preference on COTS software rather than GOTS software. This policy is expected to distribute development costs over a wider market making unit costs less expensive thereby saving the government money. This objective addresses this policy by striving to integrate standards into COTS software.

Success of this objective is dependent on the success of Goal 5. The COTS software vendors will need to implement standards consistently to insure the benefits of interoperability. COTS software vendors will be encouraged to implement object standards in their automated engineering tool products.

Strategy 3.1.1 Include COTS Vendors in Standards Planning

The COTS software community has not eagerly adopted standards developed without consulting COTS software manufacturers. The IAI had difficulty attracting adoption of early standards by COTS software manufacturers due to the expense of changing internal code to comply with the new standards. When COTS vendors are included in the planning stage of standards development, they provide valuable insight into the needs of the market. This insight has the benefit of early adoption of the standards by COTS software and eager customers who desire the new functionality of the software.

Object standards planning will include COTS software developers. Software vendors supplying products to CADD, GIS, and FM customers will be invited to participate in discussion to determine priorities for object standardization.

Strategy 3.1.2 Solicit COTS Vendors' Comments to Draft Standards

Just as COTS software developers are valuable in the planning of standards development, they are just as valuable in providing comments to draft standards. Draft standards provide developers an early

view of standards. COTS software developers will alert the standards team when the draft standards would cause an unacceptable investment to implement.

The COTS software vendors will be invited to participate in reviewing and commenting on draft standards. Their comments will be seriously considered and will be adopted except when the comments are clearly self-serving. It will be the burden of the project manager to show clear reason to ignore comments from a COTS software developer.

Objective 3.2 Promote Enterprise Tool Interoperability through utilization of COTS Software

As COTS vendors introduce compliant automated engineering tools, the Center will promote the use of these tools. Promotion will occur though the operations of the Center with customers, training, and products of mission support projects.

Strategy 3.2.1 Use Compliant COTS Software in Training Courses

When possible, the Center will demonstrate and use standards compliant software tools in all training courses. If COTS software is not available that complies with acted Center standards, Center instructors will alert students of the deviations from the standards in the products used in the course and demonstrate limitations encountered when not using standards compliant software.

Strategy 3.2.2 Deliver Products that use COTS Compliant Software

The Center will deliver products that require use of standards compliant software tools. Mission related project would deliver products to customers. All products will be developed using standards compliant software and will require use of compliant software for product maintenance.

Strategy 3.2.3 Demonstrate Compliant COTS Software

The Center will demonstrate the benefits of using standards compliant software tools for visitors and at conferences. Limited time demonstrations will use compliant software only.

Objective 3.3 Produce and Maintain Contract Language Requiring Use of Object Standards

Acquisition of COTS software by government agencies is controlled by procurement regulations. Acquisition of COTS software by government contractors is influenced by the same regulations. The intent of this objective is to influence these regulations to make interoperable software acquisition easier and encouraged.

Strategy 3.3.1 Develop Contract Language Requiring Compliant COTS Software

The Center will develop language that can be included in contracts that requires use of interoperable software compliant with industry standards. These standards will be those that incorporate object standards.

Strategy 3.3.2 Incorporate Language Requiring Compliant COTS Software into Standard Contracting Processes and Contract Paragraphs

The Center will coordinate with procurement offices to incorporate language that encourages use of COTS engineering tools compliant with object standards.

Goal 4 (Partnering) Collaborate with other Standards Organizations

This strategic goal establishes a framework for partnering and collaboration between the Center and other government agencies, industry, and academia. The approach uses the Center as a focal point for communication between object standardization efforts and federal organizations to gather federal requirements, enter these requirements into the object standards process, evaluate draft object standards and their impact to the federal processes, disseminate completed object standards, and participate in the compliance programs. Figure 3 illustrates how the Center will be the organization that receives concerns by the users. These concerns will be incorporated into all object standards projects to affect the standards. Adopted standards will be incorporated into products by vendors.

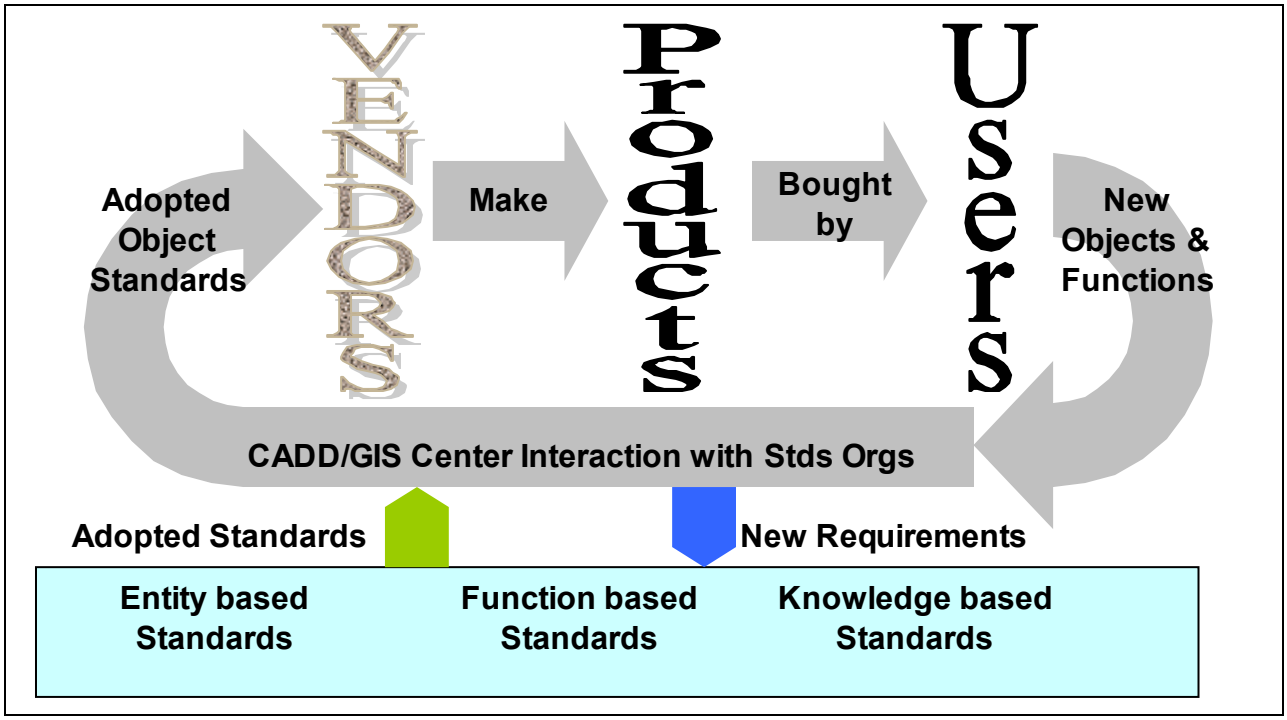

Figure 3 - Object Standards Process

Objective 4.1 Facilitate Collaboration between Standards Organizations

The Center core mission efforts for developing object standards will collaborate with recognized standards organizations. This collaboration will take the form of active participation in defining standards to develop, leading the definition of standards, providing technical analysis of developed standards, and supporting the compliance programs. These associations will expose the Center to the software vendors who will incorporate standards into their products in support of Objective 3.2.

Currently, AEC, FM, and project management domains are standardizing objects through the IAI. GIS/geoprocessing technology interfaces and geospatial data access are being standardized through the OGC. Some FM object standards efforts are being accomplished through the FMOC. Business and "simple" standards are being developed through the aecXML group. The national CADD standards are coordinated through NIBS using AIA, CSI, and the Center as technical developers.

Strategy 4.1.1 Establish Committee Chairs in Standards Organizations

The Center will become an active member of standards organizations by volunteering for chair positions of technical committees. Center object projects will leverage the work of other members in these standards organizations at the expense of delivery time.

Strategy 4.1.2 Maintain Activity in IAI

The Center has been a member of the IAI for four years and helped develop the new standards development process now used in the IAI. The Center will continue to be a leader in the IAI by continuing to chair the FM domain and the PM domain committees. The Center may need to assume additional leadership roles in the IAI as interest wanes by other government organizations.

Strategy 4.1.3 Increase Activity in OGC

The Center will need to assume a more active role in the OGC to influence object standards for GIS/geoprocessing operations. COTS GIS/geoprocessing vendors and other geospatial software developers recognize the OGC as the predominant standard organization for this technology area and are adopting their standards. There has been no active presence of the Center in OGC. In addition, there has been little work on developing object standards in the OGC. (However, the OGC understands object standards for the FIE and other domains are necessary.) Additionally, USACE joined OGC in part to coordinate the work and interests of USACE and the Center within OGC.

Strategy 4.1.4 Identify other organizations

Additional associations will be added as they emerge in the standards community. There are over 3000 standards organizations that affect automated life cycle engineering tools. Most of these organizations are waiting for major standards organizations to develop standards. The Center will limit active object standards development participation to those major standards organizations that are actively developing standards.

Objective 4.2 Facilitate Vendor Object Designs and Implementations

This objective enforces Center efforts toward a preference of COTS implementation in lieu of government software development. This will be successful if and only if the COTS implementation fully satisfies the government's requirements. These requirements are embedded in the object standards.

Strategy 4.2.1 Produce a Prototype Project to Implement a Consolidated Standard

The Center will collaborate with COTS software developers to produce a prototype system demonstrating successful consolidation of entity-based standards into entity object entities.

Strategy 4.2.2 Establish a project in OpenGIS to prototype a consolidated approach.

The Center will become an active participant in the OGC and will obtain OGC adoption of a project. The project will begin the definition of GIS objects and establish the foundation for follow on work.

Goal 5 (Quality) Establish and Enforce Object Standards Compliance Criteria

This strategic goal establishes a framework for compliance certification of object standards implementation in automated engineering tools. Once object standard compliant products are available to

users government productivity will be enhanced by the use these compliant software in future projects by government and contractor personnel. These products will be used in all phases of the project. Therefore, all personnel (government and contractors) will need to use compliant software products. The Center will coordinate will all its member organizations to ensure government personnel use compliant software. The Center will also coordinate its member organization to ensure contracting offices incorporate proper language causing contractors to use object compliant software. The result of this task will directly improve the electronic commerce operations of the federal government.

Standards require compliance and the ability to show compliance. The Center will participate in the development of standards compliance tests and evaluation of COTS products against these tests. Hopefully, in most cases this will be in conjunction with the standards development organizations. A compliance program requires establishment of the test cases that determine compliance, a facility to execute the test cases, a means to identify compliant products, a means to describe compliance, aspects of liability, and a means to improve over time. The Center's object projects will focus their contributions towards compliance programs that directly support Center standards. Use Compliance Criteria Programs of other organizations

Compliance standards and execution of compliance programs can be a costly endeavor. To reduce the cost of evaluating product compliance to object standards, the Center will partner with industry standards organizations to influence their compliance programs and augment industry compliance testing with only those tests necessary for specific government compliance requirements. An example of government compliance that industry would not necessarily include would be tests of government only operations or structures (e.g., levees, dams, and secure operations).

Strategy 5.1.1 Participate In Developing Compliance Standards In Standards Organizations

As an active member of industry standards organizations the Center will participate in the planning, design, and execution of the organization's compliance program. These programs will evaluate automated engineering tools for compliance to current standards. There may be several levels of compliance, i.e., minimum, average, or exceptional. The Center will influence development of compliance tests to include government compliance requirements.

Strategy 5.1.2 Participate In Executing Test Cases For Standards Compliance

The Center will participate in evaluating automated engineering tools for compliance. Compliance criteria will include both industry standard compliance and specific government standards compliance. It is expected that costs to perform these tests will be borne by the standards organization or the software development organization.

Objective 5.2 Model Center Criteria after other organizations

Specific government compliance criteria will be modeled after the criteria developed by industry standards organizations. This approach assists the Center to demonstrate augmentation of industry standards without duplication. In the event that no industry standard compliance exists, the Center will develop compliance criteria to assist the industry.

Strategy 5.2.1 Determine Government Compliance Criteria

The Center will discern compliance criteria into categories for industry and government. The Center will help the standards organization develop compliance evaluation measures. Procedures to measure compliance will be developed by the standards organization. The Center will develop compliance

evaluation measures that are unique to the government and will develop procedures to measure compliance using these criteria.

Strategy 5.2.2 Conduct Government Compliance Tests

Using the procedures developed in Strategy 5.2.1, the Center will negotiate with organizations developing automated engineering tools time and funding for conducting compliance evaluation tests. These tools must first be evaluated by the industry standards evaluation criteria.

Objective 5.3 Design and Trademark a Symbol

A trademarked symbol will be adopted by the Center to signify compliance with government object standards. The symbol will be displayed on the product packaging and software operation. It will be a visual marker showing the product compliance with government standards. There may be different levels of compliance. The product symbol will identify the version of date of the object standard

Strategy 5.3.1 Design a Symbol Signifying Government Compliance

The Center will develop a symbol that can be trademarked signifying compliance to government object standards. The symbol will be referenced in contract language for easy identification.

Strategy 5.3.2 Collaborate With Other Organizations To Leverage Compliance Testing

The Center will not remain the sole evaluator of automated engineering tools for the government. Other government agencies, i.e., Department of Energy, will be solicited to assist in developing compliance criteria and participate in evaluation testing.

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Appendix A

Related Projects

Core Mission Projects

Core mission projects in the Center are those that develop standards. This section summarizes the core mission project components that are using object technology or developing object standards.

Project 96.013 Spatial Data Standard for FIE (SDSFIE)

Component 9 uses an object-based tool, GeoDatabase, from ESRI to implement the SDSFIE for Camp Lejeune. The Center will prepare and publish a report of the process and the technical work necessary to migrate from the SDSFIE to an object implementation.

Component 10 will review and expand the SDSFIE symbol sets. These standard symbols will have a direct impact on the display of spatial data objects.

Project 96.015 Facilities Management Standards for FIE

Facilities Management (FM) is the requirements definition, planning, programming, design, acquisition, operations, maintenance, revitalization, evaluation, and disposal of assets which include land, water, airspace, industrial equipment, buildings, structures and utilities. The laws and regulations that define the managerial responsibilities that require a comprehensive approach to effectively manage these assets govern FM.

Component 2 will perform developmental and final data modeling of the SDSFIE/FMSFIE. Develop "physical" data models (ERWIN and “PDF” digital formats) for each SDSFIE/FMSFIE release, and develop "physical" data models to evaluate and test A/E/C CADD Standards, SDSFIE, and FMSFIE integration. This data model work can begin to address object technology issues to reduce difficulties upon conversion to objects. Component 2 is a predecessor to Component 9 of the project.

Component 4 continues to update and improvement the SDSFIE/FMSFIE software tools (e.g., Browser, Generator, Filter Maker, Translator, and Data Entry) in response to Customer requirements, and to maintain compatibility with COTS software upgrades (e.g., operating system, CADD, GIS, and database). This component will have to address objects due to the migration of COTS software to objects.

Component 9 will review and refine the attribute and domain tables developed under the A/E/C CADD Standards project for integration into a common data model with the SDSFIE and FMSFIE. This work should address the conversion to objects through the consolidated data model.

Component 10 will review, evaluate, and develop integration methodology between FMSFIE and COTS FM software and encourage COTS CADD/GIS/FM vendors to develop commercial applications based upon the SDSFIE and FMSFIE. This component will confront objects due to the migration of COTS software to object technology.

Project 96.017 A/E/C CADD Standard

The CADD standard has successfully stabilized graphic information. Non-graphic information has not been standardized due to apathy by the industry. Object standards work will need to adopt the graphic standards and introduce the non-graphic data and behaviors.

Component 1 will maintain the existing database and add changes dictated by the National CADD Committee, including graphic symbols for attributes not developed in FY00. The non-graphic portion of the database contains attributes that will become entity objects.

Project 98.245 A/E/C Objects

In FY98, the CADD/GIS Center began a core project to infuse government AEC requirements into engineering object standards being developed by the International Alliance for Interoperability (IAI), National Institute of Building Sciences (NIBS), and other organizations. The project is the Center's primary effort to collaboratively develop Object Standards using government, industry, and academic partners. The Center monitored progress of the North American Chapter of the IAI and investigated the work of all IAI Domains in FY98/FY99. The Center revitalized the Facilities Management Domain in FY99 and accelerated development of object standards by partnering with Stanford University to develop the IAI charrette process. The Center supports work in the Facilities Management (FM) Domain and the Project Management (PM) Domain.

This effort has successfully demonstrated primitive interoperability between several COTS software packages. This interoperability was complete transfer of all data between software packages without additional user data entry. The interoperability is primitive because the user had to invoke an export function in the producing software and an import function in the receiving software. Data transfer is through file. As vendors become more comfortable with interoperability, use of the operating system registry and multi-processing communications will become the interoperability vehicles. The result will be less user intervention to the point where a user is the benefactor of interoperability without having to overtly initiate the interaction.

The project also works within the aecXML committee. This group is working to standardize data content that will be used in the e-commerce aspects of AEC. AEC related companies for their benefit operate the aecXML. Bentley Systems is currently a major player and leader in the aecXML. The Center offered a DTD developed by the Facilities Manage Operating Council of NIBS to the aecXML for adoption. This DTD is available for review at http://www.aecxml.org.

Mission Related Projects

This section summarizes the mission support projects that are using or influencing object standards.

Project 98.125 Integration of CADD & GIS Standards & Digital Data

The project will perform periodic (quarterly) correlation analyses between the A/E/C CADD Standard and the SDSFIE cell libraries, attribute/domain tables, and symbologies. The project will also coordinate with the A/E/C CADD Standard developers and the SDSFIE developers to ensure that new elements (objects/features) that are common to both standards are modeled equivalently and that changes to common elements are performed synchronously.

Project 99.021 Foundation Knowledge Web Portal

This project partners with the Navy to develop a web portal for facility knowledge. The product is expected to disseminate knowledge to various management and technical levels within government and

industry. A portion of the portal knowledge should address interoperability and object technology and the portal content should be implemented using object technology.

Project 00.039 SGML Prototype for Electronic Delivery of Facilities Operation & Maintenance Information

The project attempts to achieve the following.

- Develop a prototype SGML Document Type Definition (DTD) for Facilities Maintenance & Operations standard which would address electronic delivery of manufacturers product information (O&M manuals, product specifications, troubleshooting procedures, etc.), utilization of CAFM drawings, and Commercially Available Computer Maintenance Management Systems (CMMS), (e.g., MAXIMO) to develop smart facilities and smart systems.
- Research development of CAD design standards or recommended practices for capturing manufacturing data from design through construction.
- Develop standard for electronic delivery of manufacture's information concerning installed products. Utilize online specifications to monitor and enhance system operation; reduce preventive maintenance costs by monitoring operating statistics and historical performance measurements.

These efforts are compatible with the development of XML schemas by the aecXML for conducting e-business between contractors and suppliers. XML schemas are based on object standards developed by the IAI. These schemas will need to have geo-spatial attributes that are supported by the OGC.

Project 01.016 SDS/FMS Additional Data Sets

Component 1 will add data sets to the current SDSFIE/FMSFIE schema (primarily environmental compliance, e.g., air and solid waste) to address environmental reporting and recordkeeping regulatory requirements. The first step will compare current SDSFIE/FMSFIE tables and columns to some standard environmental database schemas (such as the data model published by EPA, other models to be determined). Identify new columns and tables that will be added to SDSFIE/FMSFIE as well as any modifications to SDSFIE/FMSFIE. Additions to the SDSFIE/FMSFIE should be developed considering features of object technology and integration with other Center standards.

Project 01.039 SDS Real Property Entity Set

This project will concentrate on Work Management to augment the SDSFIE. Additions to the SDSFIE/FMSFIE should be developed considering features of object technology and integration with other Center standards.

Project 01.043 Natural Cultural Resources SDS Prototype

This project compares the SDSFIE and data requirements of the Army ITAM. The SDSFIE will be changes to support the Army ITAM. Additions to the SDSFIE/FMSFIE should be developed considering features of object technology and integration with other Center standards.

Project 01.044 Consolidated Object Strategy

The Center is working on objects in many projects and is working with standards organizations to standardize objects for interoperability. A strategy will be developed will providing a roadmap for the Center to optimize object efforts and produce products based on object technology that enforces interoperability.

Management of object standards will require a means to divorce the standards from implementing technology. A metadata model will be initiated to capture standards knowledge that can be migrated to

technologies, as they are available to engineering tool developers. Specifications for the development and documentation of metadata are provided in ISO/IEC 11179, "Specification and Standardization of Data Elements" and ANSI X3.285 "Metadata for the Management of Shareable Data." An object registry would contain CADD, GIS, and FM object metadata in compliance with ISO/IEC 11179. This registry would enable software to better interpret the data being accessed and intelligently select the capabilities of the data.

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Appendix B

Object Technology

Background

Early attempts for data sharing were attempted through file sharing. A diskette was transferred from on machine to another to enable people to use the same data. This reduced data entry, an activity that consumes a great deal of time compared to the computer's speed of data analysis. The local area network eventually replaced the diskette as a data transfer medium but engineers were still working independently and data sharing was limited to software from select vendors that cooperated to produce a data-sharing format. Current capabilities in computing technology enable a variety of users to simultaneously use the same data, if the data are in a format the software systems understand. A serious limitation to advancements in using computer technology is proprietary data formats used by software systems that support the engineering process.

Properties of an Object

Object technology is a mechanism for data sharing and protection of proprietary information. Object technology is based on newer software development technology that supports software architecture in three components. In general, software can be characterized as having a user interface, functions, and data as depicted in Figure 4. The graphical user interface component interacts with the user in a form that is both understandable and intuitive. Data structures and values are needed by the software to perform algorithms, manage process flow control, and obtain user validation. Functions are the algorithms that perform calculations and make decisions based on the data. Considering these three components will help clarify the term object as it relates to this paper.

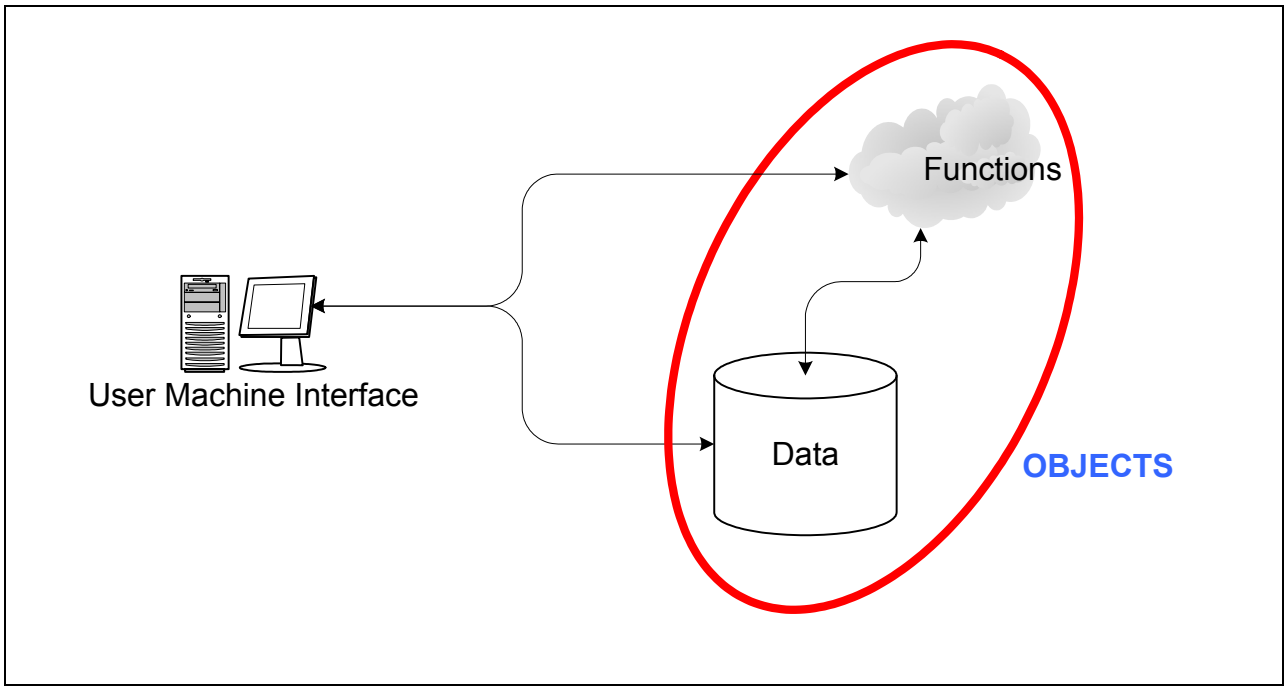

Figure 4 - General components of software

Not too long ago when a user operated a software tool, they concentrated on either the data or the behavior of the software. Concentrating on the data meant users made sure the data was appropriate and expected the software to employ the correct algorithm for the operation. Concentrating on the behavior meant that the user manipulated the data to make sure the software performed correct actions according to the desires of the user. Examples of data oriented operations are found in database applications. Examples of behavior-oriented operations can be found in prior CADD systems where the user entered whatever data and invoked whatever event to make the product look correct. Object technology attempts to relieve the user of this data vs. behavior decision by coupling, or encapsulating, the two components into an object, shown by the oval in Figure 4.

An object in software is a particular instance of an object class. Object classes are collections of reusable software that can be incorporated into software by developers. For example, a class named **Car** will contain all the data and behavior common to cars. A class named **Dog** will contain all the data and behavior common to all dogs. However, an object named FIDO is an instance of the class Dog that will contain all the data and behavior of dogs and the unique data values of the particular dog named FIDO. In engineering, a class named **Door** will contain all the data and behavior of all doors. However, the object Door1245 will contain the particular data values of the particular door for room 1245. Often these data values are not known until the object is needed, so the class will place default values for the objects in the event that particular data is not immediately available.

Object Categories

Through the life of a project, objects gain characteristics and precision. An initial object may be nothing more than a name. As information is obtained about the object, the development staff is able to add data characteristics and functions.

Entity Objects

An object that contains data elements and no operations is an entity object. Such an object is very similar to an entity in a data model.

Fully Formed Objects

Object Forms

Object classes are the tools that programmer's use to build object-oriented software. These classes can be categorized into three levels as illustrated in Figure 5. The lower level contains object classes that implement functions that inter act with the operating system, manage internal data for software operations, and interface to the computer system. The programmers employed by the COTS software developer design these classes. An example of these classes is the Microsoft Foundation Class (MFC) library or class libraries developed by vendors like AutoDesk. Not sure, we should reference any particular product in the paper, as it could be misconstrue as an endorsement of the product.

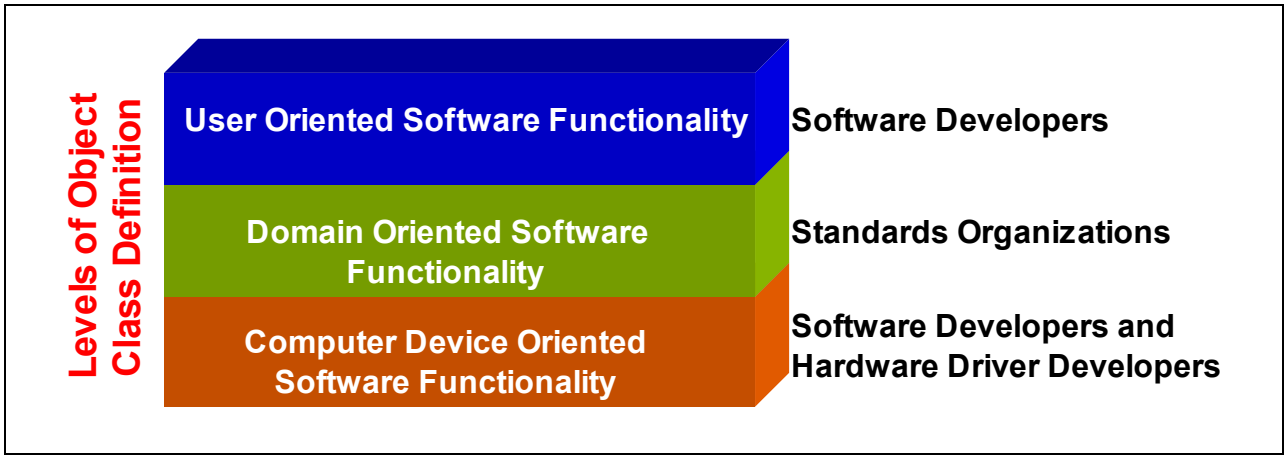

Figure 5 - Object Definition Levels

Programmer Objects

User Objects

Application Objects

The middle level object classes are those that implement the functions that support the market segment targeted by the software vendor. This class level manages the data and behavior that is common to all users in the technical domain, regardless of the software vendor. Since these object classes are common to all users, this level can provide interoperability between software systems. For engineering, these classes are the common denominator for engineering processes in all organizations. Currently, software developers define classes at this level for data and behavior using their proprietary data structure.

Top-level object classes provide value added functionality based on the middle level. These classes are produced by the various COTS software developers to perform user interface functions and functionality that differentiate their product from competitors, the innovative value added classes that use the other classes, and are implementations of operations that the vendor uses to attract buyers of their products.

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Appendix C

Glossary

Introduction

The glossary refers to terms used in this document that may not be familiar to the reader. All terms are defined from the perspective a strategic document where the audience is intended to be managers having a wide range of experience other than the technical domain of object oriented computer science.

Definitions

Aggregation
Association
Attributes
Behaviors
Entity Objects
Generalization
Interface
Messages
Object
Object Class
Object Oriented
Objective
Operations
Programmer Objects
Properties
Standard Objects
Strategy
User Objects
Vendor Objects